AEZT

IMPACT OF THE TOWN OF BRIGHTON SEWAGE TREATMENT PLANT EFFLUENT ON THE WATER QUALITY OF PRESQU'ILE BAY

County of Northumberland

rio

Ministry
of the
Environment

IMPACT OF THE TOWN OF BRIGHTON SEWAGE TREATMENT PLANT EFFLUENT ON THE WATER QUALITY OF PRESQU'ILE BAY

County of Northumberland

Field Work 1977 & 1978

Report 1981

Prepared by: K. Sherman
Water Scientist
Technical Support Section
Central Region

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

In response to a request from staff of the Municipal & Private Abatement Section, a water quality survey of Presqui'ile Bay was carried out to:

1. define the existing water quality of the bay in relation to the sewage treatment plant discharge from the Town of Brighton;

2. provide information to evaluate the water quality impact of the discharge when the facility is at design capacity;

After the survey was started, it became apparent that aquatic plant growths were causing significant problems with water use in the bay. An additional objective was then included to:

3. outline the common aquatic plant community in the bay and the extent of nuisance plant growths affecting water uses.

Appreciation is extended to Mr. A.V. Choo-Ying of the Central Region for his assistance in the hydrology section of the report.

THE SURVEY

Study Area

Presqu'ile Bay or Brighton Bay, is located on the north shore of Lake Ontario approximately 14 kilometres west of the Town of Trenton in the Township of Brighton, Northumberland County. The Town of Brighton is located on the north shore of the bay with sewage treatment facilities discharging to a small stream flowing into an extensive marsh area (the Gosport Marshes) on the north shore of the bay (Figure 1). The population of the town during the survey was approximately 3,000 people. The following are some morphometric data on the Bay and its watershed:

Surface Area (Ao)	9.1 km^2
Maximum Depth (Zm)	4.5 m
Mean Depth (Z)	1.8 m
Volume (Vo)	$16.6 \times 10^6 m^3$
Drainage Area to Bay	86.1 km^2

The bay discharges to Lake Ontario via a narrows on the southeast side of the bay. The Murray Canal connects the bay directly to the Bay of Quinte to the east. Several streams flow into Presqui'ile Bay. The two main streams are Butler Creek (also known as Proctor's Creek) and Smithfield Creek.

Presqu'ile Bay and its drainage basin are situated on limestone bedrock of the Trenton Black River formation. The area straddles the Iroquois Plain and the Prince Edward Peninsula physiographic regions (Chapman and Putnam, 1973). A significant physiographic feature of the bay is the arm-shaped peninsula that encloses the bay from the open waters of Lake Ontario. The formation of the sandy northerly section of the peninsula resulted in beach deposits and the creation of finger-like projections of land into the bay (Ernsting, 1976). The projections created many shallow water pools and bays that are presently low marsh areas.

The predominant soils throughout the upland portion of the drainage basin consist of various types of sandy loam. Muck soils predominate around most of the shoreline areas of the bay. Only a few areas of silty loam or silty clay loam are present (Hoffman and Acton, 1974).

The bay receives heavy recreational and commercial use, including the following:

1. A commercial fishery operated on the bay until recently. According to staff of the Ministry of Natural Resources. The following fish species were reported for hoopnet catches within the Bay in order of catch weight: bullheads, sunfish, yellow perch, American eels, black crappie, rock bass, white perch and suckers.

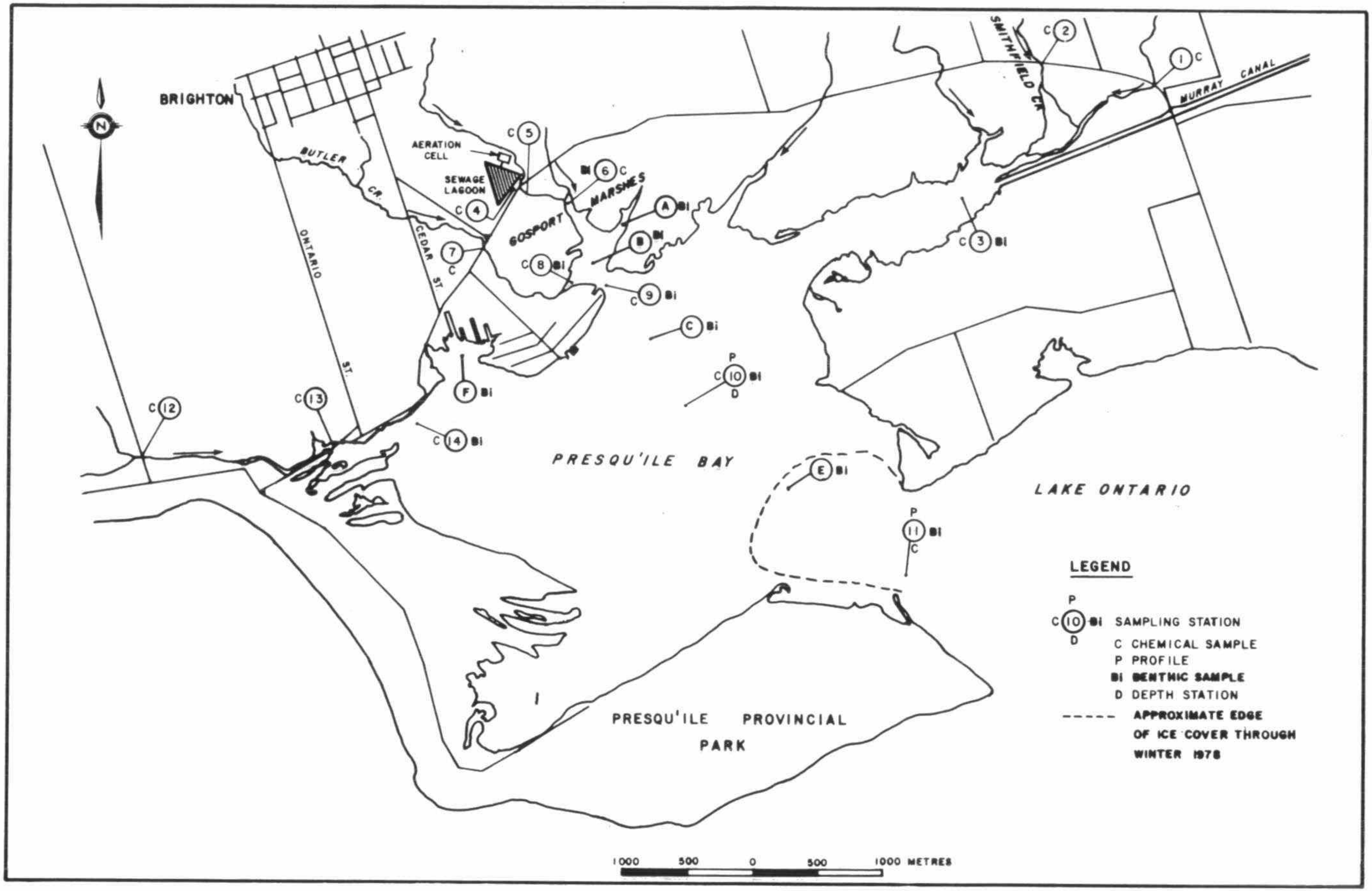

FIGURE 1: STATION LOCATIONS PRESQU'ILE BAY 1977/1978.

2. The sport fishery of the bay includes a warm water fishery for walleye, yellow perch, northern pike and smallmouth bass. Both summer and winter sport fishing occurs on the bay.

3. Presqui'ile Provincial Park occupies most of the peninsula that forms the bay with extensive beach areas on the outer shore. The park is classed as a natural environment park and the majority of park property draining to the bay is in this state. The park does have 394 tent or trailer sites. The sewage facilities serving the sites consist of holding tanks. The pumped out material from the holding tanks is disposed of outside the drainage basin of the bay. There is also one boat launch ramp on the bay side of the park.

4. The bay receives moderate pleasure craft traffic. A channel to the Trent Canal via the Murray Canal is maintained by the Trent-Severn Waterway. A Canada Customs wharf is also maintained on the bay. Two marinas and a yacht club are located on the bayshore as well as a small motel.

5. The Ministry of Natural Resources has identified several sensitive areas within the bay and its watershed. The extensive marsh area on the north shore of the bay (the Gosport Marshes), is important for water fowl, fur-bearing mammals and as part of a deer yard. Butler Creek and Smithfield Creek have both been identified as salmon and trout-spawing streams by the Ministry of Natural Resources.

6. The bay is also used for swimming where the shoreline permits.

The garbage from the Town of Brighton, Brighton Township, Murray Township and Presqui'ile Provincial Park is disposed of at the Brighton-Murray Sanitary Landfill Park, located in Lots 31 and 32, Concession 2, Brighton Township (outside the drainage basin of the bay). The site was operating satisfactorily.

Procedures

Water samples were collected at fourteen sampling locations as shown in Figure 1 at approximately three-week intervals during the study period, April, 1977 to March 1978. Station 1 was discontinued after May 17, 1977 because of the lack of flow in the stream. Stations 11 and 12 were not sampled during the ice-covered period (November 30, 1977 to March 15, 1978). Station 10 was used to represent the water quality of the main portion of the Bay.

Water samples from each station were analyzed for the following:

Parameter	Unit
Field measurements	
temperature (temp.)	°C
dissolved oxygen (D.O.)	mg/L
Secchi disc depth (S.D.) (open Bay stations)	m.
Chemical Analyses	
biochemical oxygen demand (BOD_5)	mg/L
total phosphorus	mgP/L
dissolved reactive phosphorus (DRP)	mgP/L
filtered ammonia (F.A.)	mgN/L
total Kjeldahl nitrogen (TKN)	mgN/L
nitrite nitrogen (NO_2)	mgN/L
nitrate nitrogen (NO_3)	mgN/L
hardness (hard.)	mg/L as $CaCO_3$
alkalinity (alk.)	mg/L as $CaCO_3$
total iron (Fe)	mg/L
chloride (Cl)	mg/L
pH	pH units
conductivity (cond.)	umhos/cm
sulphate (SO_4)	mg/L
turbidity (turb.)	Formazin Turbidity Units
calcium (Ca)	mg/L
magnesium (Mg)	mg/L
Bacterial Analyses	
total coliform bacteria (T.C.)	organisms/100 ml
fecal coliform bacteria (F.C.)	organisms/100 ml
fecal streptococcus (F.S.)	organisms/100 ml

Samples were collected at station 10 for phytoplankton. Compositing of samples, identification and biovolume determinations were carried out by staff of the Ministry's Phytoplankton Taxonomy Unit.

In addition to the routine sampling, the following specialized sampling was undertaken during the survey:

1. Samples of common aquatic plants collected during the summer of 1978 using Skin and Scuba divers were identified with the assistance of staff of the Limnology Section, Water Resources Branch. Quantitative samples of plants from five locations in the heavy growth areas were collected using a 0.25 m² quadrat on July 25, 1978. All plants within the quadrat were pulled out with roots as intact as possible and placed in plastic bags. Analyses of the quantitative plant samples by staff of the Water Resources Branch and Laboratory Services Branch included dry weight, per cent loss on ignition, total

phosphorus and total nitrogen. In addition to direct sampling, the apparent distribution of rooted aquatic plants was mapped using colour oblique air photos taken by MOE staff and colour vertical air photos taken by staff of the Ontario Centre for Remote Sensing.

2. Samples of the benthic invertebrates or benthos were collected using an Ekman dredge (23 x 23 centimetres). The sample was washed through a sieve of mesh size 0.65 millimetres. The organisms were then "picked" from the remaining debris using white enamel trays and preserved in 5% formalin. Identification was carried out by Central Region staff with the use of keys by Merritt and Cummins (1978), Wiggins (1977), Klemm (1972), Edmunds et al (1976), Clarke (1973), Mason (1974), Brinkhurst et al (1968) and Saether (1972).

HYDROLOGY

There were no continuous flow recording stations within the drainage basin of Presqu'ile Bay during the survey. Periodic spot flow measurements have been taken by MOE staff on Butler Creek and Smithfield Creek since 1970 (Stations 02HD100 and 02HD109 respectively). Using the Water Survey of Canada Station 02HD010 on Shelter Valley Brook near Grafton, Ontario, the Central Region hydrologist estimated flows in Butler Creek and Smithfield Creek. The estimates were made on the basis of graphical correlations between periodic spot measurements on Butler and Smithfield Creeks and the average daily flows for Shelter Valley Creek on the same day on which the spot measurement was taken. From this analysis, mean monthly flows for the period 1965 to 1976 at Shelter Valley Brook were used to estimate mean monthly flows in Butler Creek and Smithfield Creeks as well as providing a mean monthly unit flow figure for estimating flows from other parts of the Presqui'ile Bay watershed (Appendix 1). Average monthly flows during the study period at Shelter Valley Creek were slightly lower than the long-term mean monthly values calculated.

Although on occasion through the survey, it appeared that currents were moving water into the bay from the Murray Canal and from the open lake, these "inflows" were assumed to be negligible for the time frame of an average year.

BRIGHTON SEWAGE TREATMENT PLANT

Prior to June 1977, the sewage treatment facility serving the Town consisted of a single cell waste stabilization pond with a continuous discharge. The present sewage treatment facility serving the Town was completed in June 1977. Up to August 1979, the works were owned and operated as a Ministry/Municipal Project. In August 1979, the ownership and operation of the works were transferred to the Town. The sequence of sewage treatment is as follows:

1. Sewage enters an aeration cell (0.7 ha.).

2. Alum is added on a continuous basis for phosphorus removal at the outlet from the aeration cell.

3. Sewage then enters a lagoon cell (5.5 ha.).

4. After approximately 40 days (21 days at design flows) retention, effluent is discharged to the receiving stream.

The design factors used for the plant included the following:

maximum serviced population	5,500 persons
design flow (average)	3,864 m^3/day
maximum B.O.D. loading to plant	424 Kg/day
maximum suspended solids loading to plant	424 Kg/day

Sewage flows during the study and effluent quality data for 1977 and 1980 are summarized in Appendix 2. The average flow during the survey was 2,259 m^3/day. Flows have increased slightly to 2,500 m^3/day in 1980, with no significant increase in connected population.

During the survey, the STP was providing satisfactory treatment of organics with an average BOD_5 concentration (April 1977 to March 1978) of 8.8 mg/L. The effluent total phosphorus concentration for the same period averaged 1.4 mgP/L which exceeded the MOE criteria of 1.0 mgP/L. The criteria is based on the I.J.C. requirements for sewage treatment facilities discharging to recreational water bodies tributary to Lake Ontario or Lake Erie. During 1979 and 1980, because of adjustment of alum dosages at the STP, effluent total phosphorus concentration consistently met the MOE criteria with average values of 0.44 and 0.69 mgP/L respectively. Elevated filtered ammonia concentrations in the plant effluent resulted in high concentrations in the receiving body adjacent to the discharge. The un-ionized ammonia concentration (the toxic component of the filtered ammonia) averaged 0.03 mgN/L at Station 6 during the ice-free period and 0.05 mgN/L during the ice covered period. These values exceeded the MOE "Blue Book" objective for un-ionized ammonia of 0.02 mg/L in a localized area for a distance assumed to extend just beyond Station 6 (a distance of approximately 375 m. from the outfall).

SURVEY RESULTS

Water quality results are summarized in Appendix 3. The results for Station 10 were considered representative of the main portion of the Bay.

Physical Characteristics

Water clarity in the bay as indicated by Secchi disc measurements was poor with a mean value of 2.3 metres at Station 10. Turbidity in the water column at this station was lower during the ice-free period than during the ice-covered period with mean values of 1.4 and 2.4 FTU respectively.

Temperature was generally uniform through the water column at the open water station. However, slightly lower water temperatures occurred during mid-summer just next to the bottom. These lower temperatures were probably due to the shading and sheltering effect of aquatic plant growths. Temperatures during the ice-covered period tended to be slightly warmer near the bottom at deep stations.

Ice-cover extended over most of the bay from December, 1977 to March, 1978. A small open area (approximately 6 metres by 20 metres) was maintained at Station 6 because of the warmer temperature of the effluent. A large open area (see Figure 1) was always present at the mouth of the bay during the ice-covered period due to wind and wave action from Lake Ontario. Maximum ice thickness at Station 10 was 76 centimetres (33 centimetres of "slush" ice and 43 centimetres of "blue" or clear ice). Ice cover was generally uniform over the stations sampled in the open bay.

Basic Water Chemistry

Presqu'ile Bay has hard, alkaline water. Minimum hardness, alkalinity and conductivity at Station 10 were 103 mg/L as $CaCO_3$, 81 mg/L as $CaCO_3$ and 292 umhos/cm³ respectively with a minimum pH of 7.65. Both pH and alkalinity showed a marked seasonal trend (see Figure 2A) with a minimum in alkalinity concentration and a maximum in pH occurring about mid-summer. This pattern was probably caused by the uptake of inorganic carbon from the water column by the aquatic plants. The peak pH and minimum alkalinity concentration correspond to the period when maximum growth of aquatic plant beds was observed in the bay.

The water in Presqu'ile Bay was ionically balanced and well buffered. The major cation was calcium while the major anion was bicarbonate. Concentrations of dissolved ions were highest in the effluent and at adjacent stations (see Figure 3B and C).

Dissolved Oxygen

The concentration of dissolved oxygen throughout the bay was at or near saturation during the ice-free period.

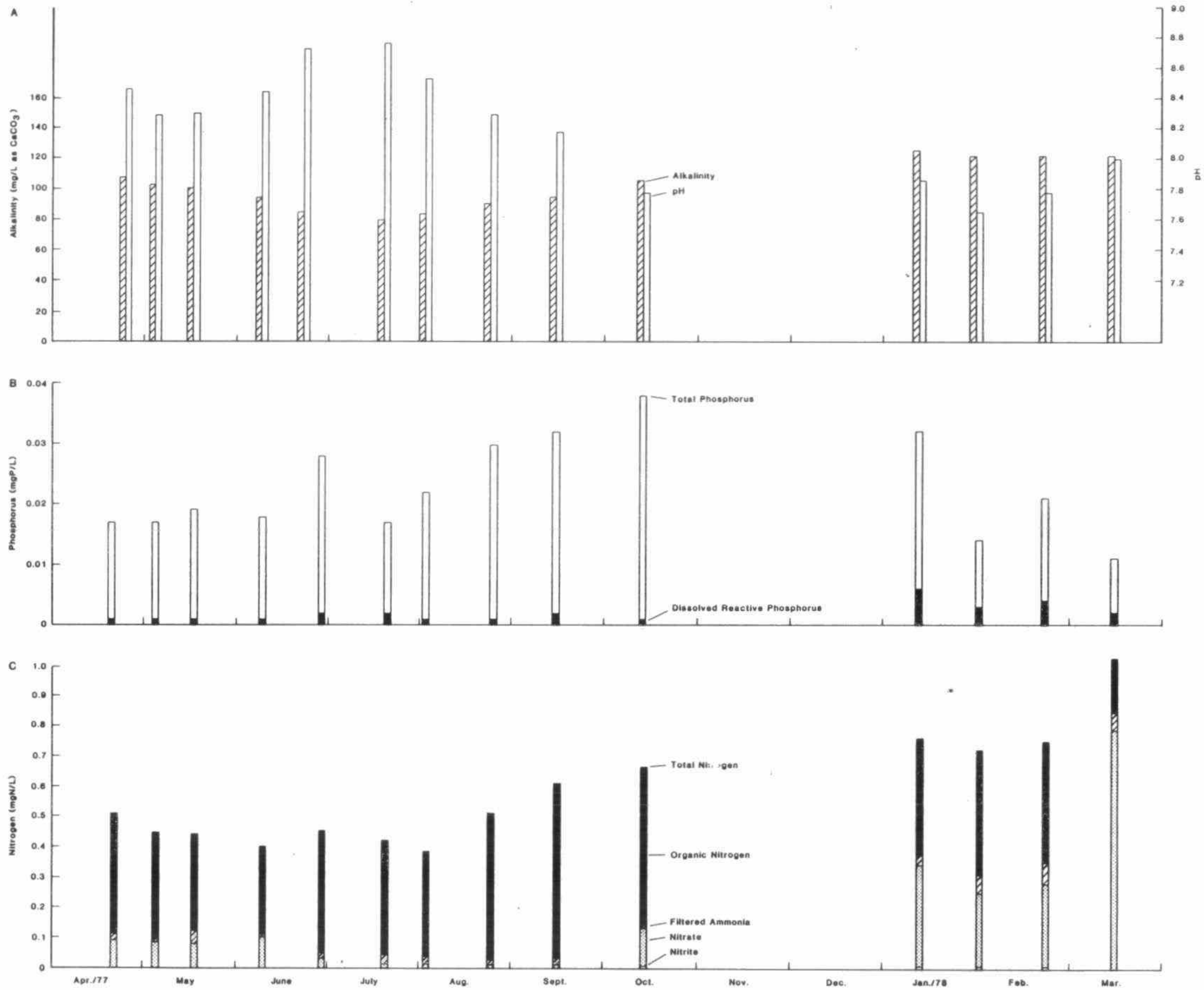

Figure 2 Seasonal Trends of selected water quality parameters at station 10 Presquile Bay 1977-78. A-Alkalinity and pH B-Total Phosphorus and Dissolved Reactive Phosphorus C-Nitrogen.

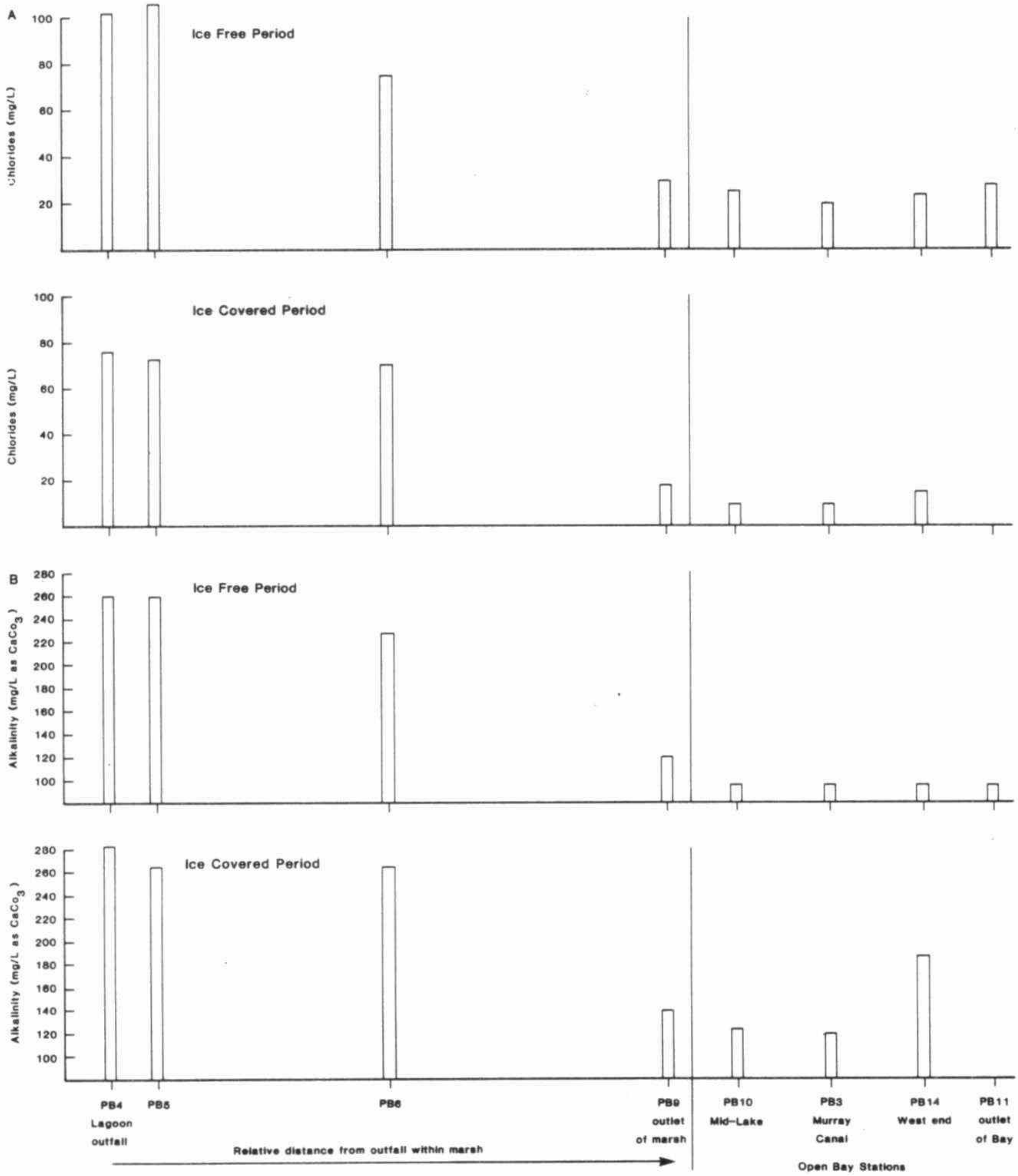

Figure 3 Mean ice-free period and ice-covered period values for selected water quality parameters in Presquile Bay 1977-78. A-Chlorides, B-Alkalinity, C-Conductivity, D-BOD_5, E-Phosphorus, F-Nitrogen.

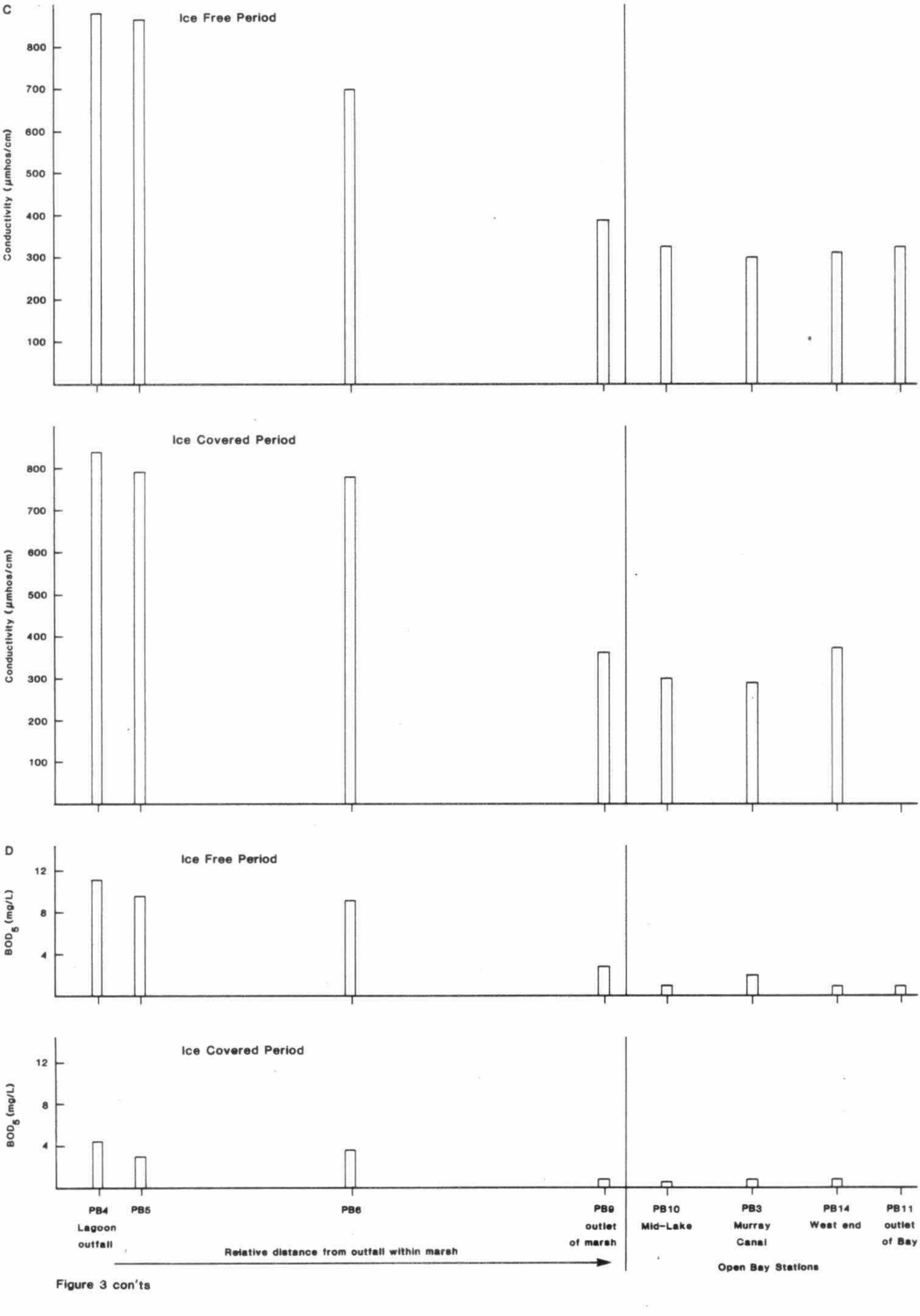

Figure 3 con'ts

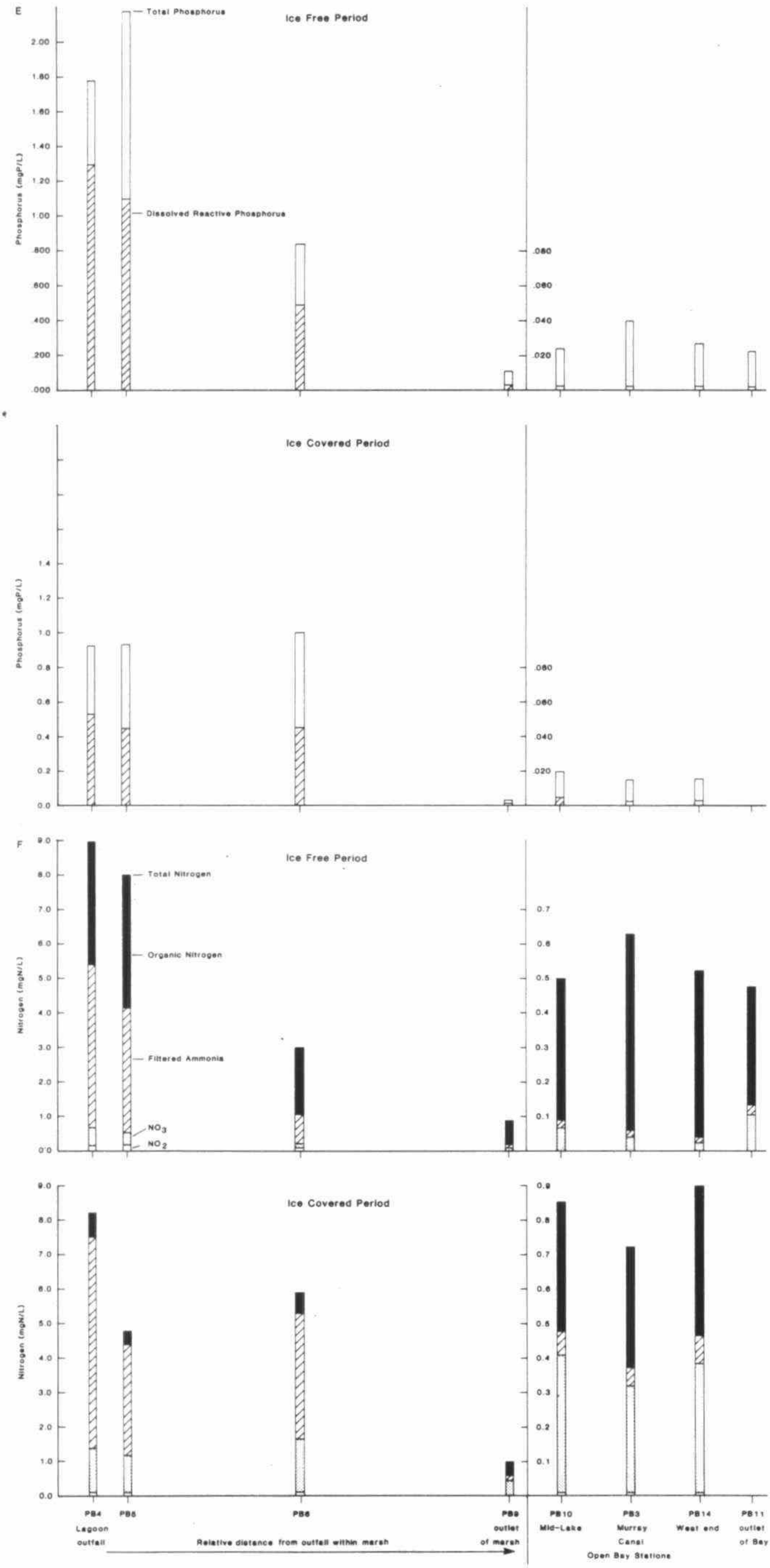

Figure 3 con'ts

During the ice-covered period there was a decline in dissolved oxygen in some small, sheltered bays and slips within Presqu'ile Bay. However, concentrations were near saturation through most of the bay. Values fluctuated most throughout the survey at stations directly influenced by the STP effluent discharge (i.e., Station 6).

The most frequent effect of the discharge of organic wastes to streams is the reduction of dissolved oxygen concentrations to levels which cannot support normal aquatic life. A measure of this oxygen demand in water is the 5-day biochemical oxygen demand or BOD_5 (defined as the dissolved oxygen required for the aerobic bacterial stabilization of decomposible organic matter in a 5-day period). A guideline that is often used by this Ministry for the maximum acceptable BOD_5 concentration in a water body is 4 mg/L. Concentrations above this value may reduce the dissolved oxygen concentration below 5 mg/L and may also cause objectionable aesthetic problems. This guideline was exceeded by a factor of 2 at Stations 5 and 6 during the ice-free period (Figure 3A). The guideline was met, however, throughout the ice-covered period at the stations. Typical BOD_5 concentrations from the open water areas and stations unaffected by the STP effluent in the marsh area averaged 1.1 to 2.7 mg/L.

Nutrients

Phosphorus has been shown to be a key nutrient that often limits the growth of phytoplankton in lakes. The open water stations in the bay with the exception of Station 3 had comparable mean total phosphorus concentrations (mean total phosphorus concentrations during the ice-free period ranged between 0.022 to 0.026 mgP/L and 0.014 to 0.020 mgP/L during the ice-covered period). Mean total phosphorus concentration during the ice-free period at Station 3 was almost twice that of Station 10 and may have resulted from the influence of the Murray Canal or the extensive marsh areas nearby. A definite trend of declining total phosphorus and dissolved reactive phosphorus concentration was noted at stations increasing in distance from the STP discharge (see Figure 3E).

It is generally accepted that total phosphorus concentrations greater than 0.020 mgP/L can result in nuisance growths of algae in lakes. Based on total phosphorus concentration in the open waters Presqu'ile Bay was considered enriched or eutrophic.

There was a noticable increase in total phosphorus concentration at Station 10 coinciding with the observed decline and die-off of the aquatic plants in the fall (Figure 2B). The release of phosphorous contained in the plant tissues may have contributed to this accumulation.

Nitrogen is also an important plant nutrient. As shown in Figures 2C and 3C, most nitrogen found at the open water stations during the ice-free period was in the form of organic nitrogen.

Stations 4, 5, 6, and 9 showed a marked decline in nitrogen concentrations with distance from the STP outfall (Figure 3F). During the ice-covered period, nitrate concentrations of two to seven times the summer values were noted at all stations. This form of nitrogen is available for plant growth but may have accumulated from land drainage, STP effluent or deomposed aquatic plants because of the limiting growth conditions of low temperatures and low light in the bay during the winter.

Unionized ammonia concentration (the toxic component of filtered ammonia) did not meet the MOE "Blue Book" objectives on several occasions at Stations 4, 5, and 6. This localized zone of non-compliance (assumed to extend to just south of Station 6) was due to the elevated ammonia concentrations in the effluent and the lack of mixing with other water in the marsh.

Bacteria

Samples taken during the ice-free period for three groups of "indicator" bacteria demonstrated that there was no apparent impact of the STP effluent on the bacteriological quality of the receiving water. Elevated bacterial densities were found on occasion at stream stations (e.g., Stations 2 and 7) and probably were caused by washing of bacteria into the streams during rainfall events in the area. According to the MOE "Blue Book" objectives for swimming and bathing use of water, a potential health hazard exists if the fecal coliform and/or total coliform geometric mean density for a series of water samples exceed 100 per 100 ml and/or 1000 per 100 ml respectively. A series of at least 10 water samples per month per sampling location is required to be certain of the mean densities found. The small number of samples taken during the survey did not allow a strict assessment of the potential for health hazard of the water for swimming use. However, samples were collected on both dry and rainy days and therefore may be representative of summer bacterial quality.

Phytoplankton

Results of phytoplankton identification and cell volume determinations for Station 10 are summarized in Appendix 4. The density of algae as indicated by biovolume determinations was moderate during the ice-free period but low during the ice-covered period (0.94 mm^3/L and 0.26 mm^3/L respectively).

During the ice-free period of 1977, the phytoplankton community was dominated by diatoms (especially Diatoma and Asterionella). The flagelate alga Cryptomonas and the blue-green algae Microcystis, Anabaena and Aphanizomenon were also well represented. All of these algae that are common in Presqu'ile Bay are known to require at least a moderate degree of enrichment to thrive. With a significant increase in the phosphorus concentration in the bay the proportion of nuisance algae such as the "blue-green bloomers" Mycrosystis, and Aphanizomenon will increase. Undesirable algae blooms may then occur.

The phytoplankton community during the ice-covered period was dominated by diatoms especially Stephanodiscus. The flagelate Cryptomonas and the blue-green algae Aphanizomenon were also common.

Based on the overall density and composition of algae, Presqu'ile Bay was considered moderately enriched.

Benthic Invertebrates

Knowledge of the organisms living in a water body for all or a large part of their life cycles provides an important indication of continuous water quality conditions. Benthic invertebrates (bottom-dwelling organisms without backbones) are influenced by several physical, chemical and biological factors in a lake or stream. Results of samples taken near the STP discharge as well as in the open waters of the bay are presented in Appendix 5.

In general, the common organisms in Presqu'ile Bay were the midge larvae Chironomus, worms (especially Limnodrillus hoffmeisteri), the sow bug, Asellus and other midge larvae such as Cryptochironomus, Glyptotendipes and Polypedilum. The diversity of organisms was always at least twice as high at the open stations than at stations within the marsh area. There was no apparent pattern in the density of organisms found in the marsh area or in the open bay. The lower diversity of organisms in the marsh area may have related to the lack of beds of submerged plants at these stations. Many organisms found at the open water stations are known to be directly associated with submerged aquatic plants.

According to Brinkhurst et al. (1968) the midge larvae Chironomus and the worm Limnodrillus hoffmeistri are generally considered tolerant to poor water quality conditions while the larvae Micropsectra is considered intolerant to poor water quality conditions. According to Saether's (1975) table relating midge larvae species to trophic status the common midge larvae found in Presqu'ile Bay are generally found in mesotrophic to eutrophic conditions but some organisms such as Micropsectra are found in oligotrophic conditions. Based on the mean density of benthos at stations in the open bay of 2848 organisms per square metre (range at 6 stations of 726 to 9547 organisms/m^2) and the species composition, the bay was considered enriched or eutrophic.

Rooted Aquatic Plants

Aquatic plants are an important part of the life of Presqu'ile Bay. The submerged and emergent plants support fish food organisms, provide protective cover for fish and provide fish spawing and nursery areas. Aquatic plants are also important in "tying up" nutrients that would otherwise be available for nuisance growths of algae. Many species of rooted plants grow well below the water surface and normally do not cause any nuisance for recreational uses. Some plants grow to nuisance proportions and interfere with other uses of the water body. When nuisance growths occur, it is sometimes necessary to control a problem plant.

A list of submerged aquatic plants found growing in Presqu'ile Bay during 1978 is tabled in Appendix 6. The most common plants found in the bay were the narrow leafed pond weeds, Potamogeton strictifolius, P. pusillus and P. friesii; species commonly called "eel grass".

There is little information on the biology of these three species in the literature. According to Haynes (1974) the plants are functionally annual (i.e., they die off and grow new plants each year). During the winter, the plants in the spring exist as winter buds and/or seeds. Reproduction of new plants is probably a combination of growth from winter buds and seeds. The three plants are common to hard water lakes like Presqu'ile Bay.

The narrow leafed pondweeds grow to the surface in heavy growth areas of the bay and have a characteristic yellow-green colour. These features allowed an approximately delineation of heavy growth areas (Figure 4). Areas where plants grew to a height that did not reach the surface and may not have caused navigation problems were termed moderate and areas with plants growing close to the bottom or with no plants were termed as sparse growth areas. The area covered by heavy growths of aquatic plants occupied most of the navigable water in the Bay (54% of the total surface area).

Results of quadrat samples taken of representative areas of heavy growth are shown in Appendix 7. Densities of plant beds on a dry weight basis were lower than heavy growth areas of Chemung Lake, Peterborough County (Wile and Hitchin, 1977). The approximate amount of phosphorus tied up in the plant tissues is 0.77 grams per m^2. Assuming this value is representative of the entire heavy growth area in the bay, about 4500 kilograms of phosphorous is tied up in plant tissues in this area.

There are two weed control methods that are feasible for use in Presqu'ile Bay.

1. Chemical control using aquatic weed herbicides.

2. Mechanical weed harvesting.

In June, 1978, a chemical application was carried out at the expense of Parks Canada to clear the channel from the mouth of the Murray Canal to the open lake. In the past, there have been applications of herbicides on localized shoreline areas by individual property owners. Use of herbicides on large areas of the bay is not recommended because of the undesirable water quality effects of the treatment (i.e. algae blooms).

Mechanical weed harvesting has been shown to be effective in controlling weeds in large areas of Chemung Lake, Peterborough County with no adverse ecological effects (Wile and Hitchin, 1977). A disadvantage of this method is that localized shoreline areas cannot be effectively harvested with machines.

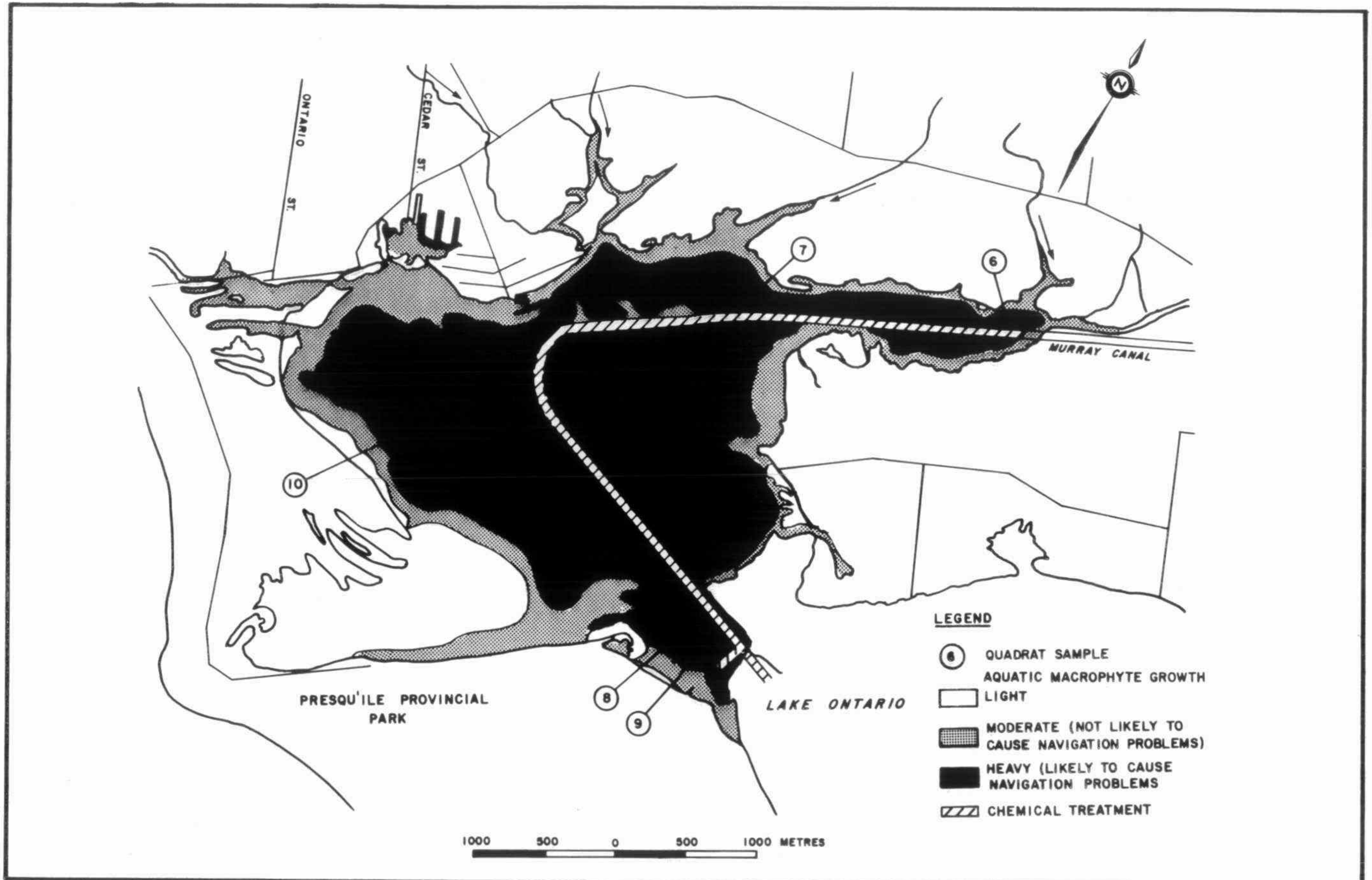

FIGURE 4 : AQUATIC MACROPHYTE GROWTHS IN PRESQU'ILE BAY 1978

WATER QUALITY OF PRESQU'ILE BAY IN RELATION TO THE BRIGHTON SEWAGE TREATMENT PLANT DISCHARGE

Water Quality Status

Based on physical, chemical and biological indicators, Presqu'ile Bay had enriched or eutrophic water quality conditions during the study period. MOE objectives or guidelines for BOD_5 concentration and un-ionized ammonia concentration were not met in a localized area adjacent to the STP outfall. The MOE guideline for total phosphorus concentration of 20 ug/L was not met at all stations during the survey, even at stations that were not affected by the STP discharge.

Heavy growths of three species of narrow leafed pond weeds were creating a nuisance to navigation and other water uses over extensive areas of the open bay. The plant beds were noted to influence the basic water chemistry and nutrient conditions of the open bay. As rooted aquatic plants are known to maintain high growth rates even with low nutrient concentrations in the surrounding water, the weed problems in the bay were not thought to be associated with the STP discharge.

Phytoplankton growths were moderate but the common genera present included forms that could if the phosphorus concentration in the water were significantly increased, cause undesirable algae blooms in the bay.

Effects of the STP Discharge on the Water Quality of the Bay

To assess the importance of the STP discharge to the bay, the amount of phosphorus entering the bay from various sources was calculated as in Appendix 8.

The following table shows the significance of each source under different STP loadings.

Table 1

Source	Phosphorus Supply Kg/yr.	Phosphorus Supply % of total
Land drainage	876.9	35.6
Precipitation	456.8	18.5
STP^x	1,044.4	42.4
Cottages*	27.6	1.1
Permanent Dwellings*	60.0	2.4
Total	2,465.7	

xflow and quality conditions 1977-78
* not serviced by Brighton STP

Table 1 indicates that during the study period the STP effluent was the largest single source of phosphorus supplied to the bay. With the effluent total phosphorus concentration meeting the MOE guideline of 1.0 mgP/L, the STP component of the budget would become approximately 825 Kg/yr or the second largest source of supply. The data for 1979 and 1980 indicate that less phosphorus than this amount was supplied to the bay from the STP. When the STP reaches design flow and with an effluent total phosphorus concentration of 1.0 mgP/L, it will increase total supply to the bay over study conditions by 15 per cent.

It is interesting to note that the phosphorus "tied up" in the tissues of rooted aquatic plants growing in the bay (estimated at 4500 kilograms in 1978 heavy growth zone) represents almost two times the total annual supply to the bay. As the majority of the plants growing in the bay die and decompose almost completely each year, the plant tissue phosphorus must in part be released to the water column. This release may explain the elevated total phosphorus concentration noted at Station 10 during the late summer and fall (Figure 2B).

The calculated effect that the Brighton STP could have on the water quality of the bay when design flows are reached is indicated in Appendix 9. The calculated values can only be considered as indicating the relative extent of change in water quality conditions in the bay rather than the absolute change expected. With the increase in sewage flows to design flows, and at an effluent total phosphorus concentration of 1.0 mg/L, it is estimated that the spring total phosphorus concentration may rise in the open bay by 13 per cent. This increase will probably result in a minor degradation of the water quality of Presqu'ile Bay (i.e. increase in the density of phytoplankton, decrease in water clarity). However, fluctuations in water quality conditions caused by the growths of aquatic plants in the bay may mask this water quality degradation in the open bay.

The Importance of the Marshes

The marshes receiving the STP discharge aid in diluting and retarding the movement of the effluent toward the open bay. The marshes are potentially important in reducing the concentration of organics and plant nutrients before the effluent reaches the open bay (see Figure 3D, E, F).

Unlike phosphorus, a biologically active nutrient that is taken out of the water by the growth of aquatic plants, chlorides are not appreciably taken up by aquatic plants. The only reason that the chlorides concentration or load carried between two points will significantly decrease is because of dilution by water of lower chlorides concentration.

An analysis of total phosphorus and chlorides indicated that a similar reduction in supply of the two substances leaving the marsh was taking place during the survey (Appendix 10). The

calculations were based only on estimated flows and survey concentrations. This suggests that no real net retention of phosphorus was taking place in the marshes, contrary to what was expected. This could be a result of the channelized route that the effluent takes through the marshes.

Provided that the BOD_5 concentration in the effluent averages 15.0 mg/L or less at capacity, no further organic impairment of water quality is expected at the existing localized zone of effect in the marsh. The objective for un-ionized ammonia concentration will likely not be exceeded in waters beyond the existing localized zone of effect in the marsh. The Town may wish to investigate a modification of the path that the effluent travels so that more effective use of the marsh in reducing organics and ammonia concentrations is made.

The marshes were definitely providing a valuable buffer zone between the effluent and the open bay in which the impact of the effluent organics was being reduced. It is recommended that the filling of the marsh not be permitted to ensure the continued use of the marsh in this capacity.

CONCLUSIONS AND RECOMMENDATIONS

1. The water quality status of Presqu'ile Bay was considered enriched or eutrophic during the study. A localized area of impairment was noted adjacent to the STP effluent where elevated concentrations of BOD_5 and un-ionized ammonia were found. The MOE guideline for total phosphorus concentration in lakes was not met at all stations sampled, even at stations not affected by the STP discharge. Heavy growths of a group of narrow leafed pond weeds were creating a nuisance to navigation and other water uses over extensive areas of the bay. These plant beds were also noted to influence the basic water chemistry and nutrient concentrations of the open bay.

   With the additional phosphorus supply from the STP at design capacity, it is expected that a minor degradation in water quality over the bay may occur but that this degradation may be masked by the water quality influence of aquatic plant beds.

2. The total phosphorus concentration in the STP effluent should be maintained at 1.0 mg/L or less to minimize the water quality impact of the existing plant at design flow. The STP is presently meeting this requirement. The BOD_5 concentration in the effluent should be maintained at 15.0 mg/L or less when the plant is at design flow.

3. It is recommended that filling of the marshes into which the STP discharges not be permitted, to ensure the continued use of the marshes in diluting and treating the effluent before it reaches the open bay. Moreover, the Town may wish to consider modifying the path that the effluent takes to better utilize the marsh in reducing effluent organics, ammonia concentrations and possibly total phosphorus concentration.

4. It is recommended that both chemical and mechanical methods be pursued to control nuisance aquatic plant growths in Presqu'ile Bay. Use of registered aquatic herbicides is advised for localized shoreline areas. Application of a herbicide must be done only after a permit for the specific location has been obtained from the District Pesticides Officer of this Ministry. Mechanical weed harvesting is recommended for use in open areas to cut channels giving access between the open bay and cottage areas. The objective must not be to "clear cut" weeds from all areas that impede water use, because of the undesirable water quality effects this course could have on the bay.

5. A review of the water quality implications of any expansion of the existing Brighton STP facilities will be undertaken when proposed to ensure that significant degradation of the water quality of Presqu'ile Bay is prevented.

REFERENCES

1. Brinkhurst, R.O., et al. 1968. Components of the Bottom Fauna of the St. Lawrence, Great Lakes. Great Lakes Institute, University of Toronto PR 33.

2. Chapman, L.J. & Putnam, D.F. 1973. The Physiography of Southern Ontario. 2nd Edition. University of Toronto Press.

3. Clarke, A.H. 1973. The Freshwater Molluscs of the Canadian Interior Basin. Malacologia 13(1-2): 1-509.

4. Dillon, P.J. 1975. A manual for Calculating the Capacity of a Lake for Development. MOE. Report.

5. Edmunds, G.F. Jr., et al. 1976. The Mayflies of North and Central America. University of Minnesota Press. Minneapolis.

6. Ernsting, J. 1976. Reconstruction of the Development of Presqu'ile Tombolo Unpublished B.Sc. Thesis, Queen's University. Kingston.

7. Haynes, R.R. 1974. A Revision of North American Potamogeton Subsection Pusilli (Potamogetonaceae). Rhodora 76 (808): 564-649.

8. Hoffman, D.W. and Acton, C.J. 1974. The Soils of Northumberland County. Report No. 42 of the Ontario Soil Survey. Research Branch, Agriculture Canada and the Ontario Agricultural College.

9. Klemm, D.J. 1972. Freshwater Leeches (Annelida: Hirundinea) of North America. Biota of Freshwater Ecosystems Identification Manual No. 8. U.S. Environmental Protection Agency.

10. Mason, W.T. 1973: An Introduction to the Identification of Chironomid Larvae. U.S. Environmental Protection Agency.

11. Meritt, R.W. & Cummins, K.W. 1978: An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Co. Dubugue, Iowa.

12. Nicholls, K.H. 1976. Comparative Limnology of Harp and Jerry Lakes. Adjacent Cottaged and Uncottaged Lakes on Southern Ontario's Precambrian Shield. MOE report.

13. Saether, O.A. 1972. Chaoboridae. in Elster H.J. and Ohle, W. (eds.) Das Zooplankton der Binnengewasser. Die Binnengewasser 26: 257-280.

14. Saether, O.A. 1975. Nearctic Chironomids as indicators of lake typology. Verh. Internat. Verein. Limnol. 19: 3127-3133.

15. Wiggins, G.B. 1977: Larvae of the North American Caddisfly Genera (Trichoptera). University of Toronto Press.

16. Wile, I. and Hitchin, G. 1977. An Assessment of the Practical and Environmental Implications of Mechanical Harvesting of Aquatic Vegetation in South Chemung Lake. MOE-MNR Report.

17. MOE "Blue Book" - WATER MANAGEMENT - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment, November 1978. Ministry of the Environment publication.

KS/ns/REPT 4-A

Appendix 1

ESTIMATES OF FLOWS TO PRESQU'ILE BAY

Shelter Vally Brook near Grafton - Station 01HD010, Drainage Area 64.75 Km^2 (25 mi^2)
- mean values for each month over the period 1965 to 1976

	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
(cfs)	28.2	34.9	66.3	56.1	29.7	22.0	18.1	14.5	15.8	19.9	26.3	28.5	29.9
(m^3/s)	0.80	0.99	1.88	1.59	0.84	0.62	0.51	0.41	0.45	0.56	0.74	0.81	0.85

Using graphical correlations between spot measurements at either Butler Creek or Smithfield Creek and values for Shelter Valley Brook for the same day that the spot measurement was taken, the above average values for Shelter Valley Brook were correlated to the Butler and Smithfield average values as follows:

Butler Creek below Brighton - Station 02HD100, Drainag area 30.3 Km^2 (11.7m^2)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
(cfs)	8.5	10.7	21.8	18.2	8.9	6.2	4.8	3.6	4.0	5.5	7.7	8.6	9.0
(L/sec)	241	303	617	515	252	176	136	102	113	156	218	243	155

Smithfield Creek near Brighton - Station 02HD109, Drainage Area 18.9 Km^3 (7.3 mi^2)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
(cfs)	7.3	9.9	21.8	18.0	7.8	5.0	3.5	2.1	2.6	4.1	6.6	7.4	7.9
(L/sec)	207	280	617	509	221	142	99	59	74	116	187	209	224

Unit flow - calculated from Butter Creek and Smithfield Creek

	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
(cfs/mi^2)	0.83	1.08	2.29	1.90	0.88	0.59	0.44	0.30	0.35	0.50	0.75	0.84	0.89
(L/sec/Km^2)	9.1	11.8	25.0	20.8	9.6	6.4	4.8	3.3	3.8	5.5	8.2	9.2	9.7

KS/ns/REPT4-B-1

Appendix 2

FLOW AND EFFLUENT QUALITY FOR BRIGHTON STP 1977 TO 1980*

Month	Monthly Flow During Study m^3/mo.	Total Phosphorus Concentration (mgP/L) 1977	1978	1979	1980	BOD_5 Concentration (mg/L) 1977	1978	1979	1980	Total Kjeldahl Nitrogen (mgN/L) 1977	1978	1979	1980
Jan.	101,735	-	1.4	0.36	0.60	-	5.2	3.5	6	-	8.8	19	11.0
Feb.	73,524	-	1.1	0.32	0.40	-	6.0	6.0	7	-	8.4	15	1.3
Mar.	108,098	-	0.9	0.64	1.10	-	5.8	8.0	14	-	6.3	7.4	17.0
Apr.	75,000	1.4	-	0.34	0.40	18.0	-	10.0	6	7.7	-	6.6	1.6
May	45,070	2.1	1.6	-	0.32	4.0	22.0	-	5	15.0	1.5	-	2.5
June	35,430	2.7	-	0.70	0.60	7.5	-	6.0	5.8	11.6	-	10.0	2.8
July	32,395	1.6	-	-	-	13.0	-	-	-	9.4	-	-	-
Aug.	40,860	1.5	3.3	-	-	6.0	4.0	-	-	5.0	7.5	-	-
Sept.	57,270	1.3	-	-	0.90	28.0	-	-	6	5.3	-	-	11.0
Oct.	74,680	0.9	2.4	0.35	1.00	4.0	4.0	14.0	5	4.4	11.0	1.8	12.0
Nov.	83,280	0.8	1.5	0.32	0.80	3.0	2.2	5.0	11	7.1	13.0	4.5	12.0
Dec.	97,247	1.1	0.48	0.48	0.80	4.5	4.5	6.0	6	7.4	11.1	9.2	6.3
Total	824,589												
Mean	2,259 m^3/day	1.5	1.55	0.44	0.69	9.7	6.7	7.3	7.2	8.1	8.5	9.2	7.8

*Data from samples collected during study period (April to December 1977 and January to March 1978) were combined with results of samples taken by the plant operator. All other results are from plant operators.

KS/ns/REPT4-B-2

Appendix 3, Page 1

PRESQU'ILE BAY SAMPLING RESULTS 1977 AND 1978
(all results in mg/L unless otherwise noted)

Station 1

	D.O.	Temp. °C	BOD_5	Bacteria/100 ml T.C.	F.C.	F.S.	Phosphorus Total	DRP	Nitrogens F.A.	TKN	NO_2	NO_3	Hard.	Alk.	Fe	Cl	pH	Cond. (umhos/cm)	SO_4	Turb. (F.T.U.)	Ca	Mg
Apr. 20			0.8				.023	.007	.010	.44	.001	.009	254	238	.07	28.0	8.22	570			91	6.5
May 4	10.7	18.6		250	16	8	.025	.007	.006	.45	.002	.005	263	240	.05	29.0	8.29	580	22.5	1.2		
May 17	7.1	20.0	1.4				.061	.016	.032	.68	.002	.008	233	217	.24	27.0	7.86	530	17.5	2.0	81	7.5

Station 2

	D.O.	Temp. °C	BOD_5	Bacteria/100 ml T.C.	F.C.	F.S.	Phosphorus Total	DRP	Nitrogens F.A.	TKN	NO_2	NO_3	Hard.	Alk.	Fe	Cl	pH	Cond. (umhos/cm)	SO_4	Turb. (F.T.U.)	Ca	Mg
Mean Ice-free Period	9.1	17.9	1.4	1,065	100	111	.033	.003	.028	.46	.005	.286	207	187	.34	29.1	8.19	473	20.6	3.9	67	9.8
Mean ice-covered Period	12.4	0.5	0.7				.030	.008	.057	.45	.006	1.06	213	194	.30	22.2	7.92	464	22.9	4.2	71	7.0
Maximum	13.0	27.5	2.5	7,400	1,500	1,700	.084	.015	.242	.80	.012	1.40	257	223	.85	36.5	8.40	550	31.0	7.6	88	11.5
Minimum	6.2	0.0	0.1	100	10	16	.012	.001	.004	.32	.003	.074	169	161	.11	20.0	7.72	420	14.0	1.7	51	7.0

Station 3

	D.O.	Temp. °C	BOD_5	Bacteria/100 ml T.C.	F.C.	F.S.	Phosphorus Total	DRP	Nitrogens F.A.	TKN	NO_2	NO_3	Hard.	Alk.	Fe	Cl	pH	Cond. (umhos/cm)	SO_4	Turb. (F.T.U.)	Ca	Mg
Mean Ice-free Period	9.1	18.2	2.0	35	3	3	.040	.001	.016	.59	.002	.036	121	97	.15	28.0	8.36	300	23.9	3.8	37	6.2
Mean Ice-covered Period	13.5	0.5	0.5				.014	.002	.050	.41	.004	.314	131	117	.11	8.4	7.81	285	18.6	2.4	44	4.5
Maximum	14.9	26.5	4.0	144	8	4	.060	.003	.110	.97	.005	.601	146	127	.23	?79?	8.81	340	27.5	4.6	49	7.5
Minimum	5.3	0.0	0.2	10	2	2	.006	.001	.004	.24	.001	.005	94	72	.09	7.0	7.52	238	15.5	1.3	30	4.5

Station 4 (Lagoon Effluent)

	D.O.	Temp. °C	BOD_5	Bacteria/100 ml T.C.	F.C.	F.S.	Phosphorus Total	DRP	Nitrogens F.A.	TKN	NO_2	NO_3	Hard.	Alk.	Fe	Cl	pH	Cond. (umhos/cm)	SO_4	Turb. (F.T.U.)	Ca	Mg
Mean Ice-free Period	9.1	19.4	11.0	1,093	141	131	1.76	1.29	4.67	8.23	.157	.518	293	262	.33	102	8.36	867	39.3	7.4	93	14
Mean Ice-covered Period	10.3	1.6	4.4	7,741	1,130	296	.93	.525	6.11	6.79	.065	1.30	296	281	.25	74	7.88	834	50.6	5.2	91	10
Maximum	20.0	29.0	28.0	18,000	1,420	720	2.78	2.35	10.9	12.25	.65	3.85	350	315	.52	118	9.15	990	8.35	13.0	107	15
Minimum	3.4	0.5	2.0	90	4	44	.072	.041	.194	.69	.009	.021	216	170	.11	36.5	7.74	491	18.5	2.6	71	7

PRESQU'ILE BAY SAMPLING RESULTS 1977 AND 1978
(all results in mg/L unless otherwise noted)

	D.O.	Temp. °C	BOD_5	Bacteria/100 ml T.C.	F.C.	F.S.	Phosphorus Total	DRP	Nitrogens F.A.	TKN	NO_2	NO_3	Hard.	Alk.	Fe	Cl	pH	Cond.	SO_4	Turb.	Ca	Mg
Station 5																						
Mean Ice-free Period	8.9	19.3	9.6	10,262	170	391	2.16	1.10	3.61	7.49	.174	.349	296	260	.47	105	8.37	858	37.6	9.6	96	13.1
Mean Ice-covered Period	10.8	0.9	2.8				.92	.435	3.20	3.59	.050	1.19	303	267	.37	73	7.95	784	36.0	5.6	101	10.2
Maximum	13.7	29.0	25	24,000	1,500	1,500	8.1	2.23	9.6	15.7	.93	1.55	321	315	1.65	150	9.06	990	47.5	18	108	15
Minimum	6.4	0.0	1.2	4,400	10	52	.44	.295	.19	2.50	.023	.035	261	222	.17	63	7.75	630	11.0	3.2	79	7.5
Station 6																						
Mean Ice-free Period	10.5	20.1	9.2	304	25	18	.836	.594	.848	2.828	.065	.125	257	225	1.46	74	8.09	702	29	14.6	87	11.1
Ice-covered Period	11.5	0.50	3.5				1.05	.445	3.63	4.19	.047	1.57	283	263	.44	70	7.84	770	39.4	6.6	91	9.5
Maximum	16.8	31.5	23.0	1,000	80	140	2.60	1.40	6.75	7.60	.325	2.67	320	303	3.30	108	8.95	875	50	24	111	13.5
Minimum	4.0	0.2	1.5	140	10	4	.112	.029	.008	.90	.002	.005	214	183	.17	49	7.49	540	17	5.3	69	7.5
Station 7																						
Mean Ice-free Period	10.6	20.0	0.9	1,709	71	61	.034	.011	.035	.38	.008	.630	226	201	0.30	44.0	8.29	559	21.3	4.5	73	10.3
Mean Ice-covered Period	12.4	0.7	1.5				.036	.010	.059	.58	.005	1.15	236	216	2.31	41.1	8.09	565	25.3	22.4	79	8.0
Maximum	15.0	26.3	6.5	10,800	1210	1000	.100	.026	.162	.75	.022	1.37	290	250	7.8	54	8.49	720	32.5	9.3	99	13.5
Minimum	5.5	0.0	0.2	300	10	4	.012	.003	.004	.14	.003	.183	188	179	0.07	31.5	7.72	480	15.5	1.5	57	7.5
Station 8																						
Mean Ice-free Period	11.1	17.7	2.7	736	33	43	.075	.017	.036	.62	.006	.231	229	203	.87	48.5	8.05	572	22.2	8.7	74	10.3
Mean Ice Covered Period	12.6	0.2	1.0				.093	.014	.049	.68	.005	1.240	231	213	1.35	37.9	7.88	546	24.0	13.8	76	7.8
Maximum	1.70	30.0	7.5	5,500	228	308	.296	.049	.114	1.64	.018	1.34	290	249	1.35	68.0	8.53	700	33.5	36	99	11.5
Minimum	7.0	0.0	0.2	100	4	4	.020	.001	.002	.27	.001	.005	161	158	.13	33.5	7.60	425	14.0	2.3	48	7.0

KS/ns/REPT 4-B-4

PRESQU'ILE BAY SAMPLING RESULTS 1977 AND 1978
(all results in mg/L unless otherwise noted)

Station 9	D.O.	Temp. °C	BOD_5	Bacteria/100 ml T.C.	F.C.	F.S.	Phosphorus Total	DRP	Nitrogens F.A.	TKN	NO_2	NO_3	Hard.	Alk.	Fe	Cl	pH	Cond.	SO_4	Turb.	Ca	Mg
Mean Ice-free Period	9.1	18.3	2.6	310	5	16	.106	.024	.033	.77	.005	.019	144	121	.37	29.0	8.24	383	23.3	7.0	46	7.1
Mean Ice-covered Period	12.5	0.5	0.5				.034	.010	.104	.53	.005	.485	174	141	.21	17.3	7.80	358	20.8	3.4	63	6.3
Maximum	13.7	29.0	4.5	1,600	16	110	.226	.115	.334	1.40	.013	.941	201	176	1.00	38.0	8.35	520	30.5	14.0	69	8.5
Minimum	5.6	0.0	0.2	100	4	4	.016	.001	.004	.42	.001	.005	121	106	.08	8.2	7.53	290	19.0	3.0	36	4.9

PRESQU'ILE BAY SAMPLING RESULTS 1977 AND 1978
(all results in mg/L unless otherwise noted)

Date	Secchi Disc (m)	D.O.*	Temp.* (°C)	BOD_5	Bacteria/100 ml T.C.	F.C.	F.S.	Phosphorus Total	DRP	F.A.	Nitrogens TKN	NO_2	NO_3	Hard.	Alk.	Fe	Cl	pH	Cond. (umhos/cm)	SO_4	Turb. (F.T.U.)	Ca	Mg
Station 10																							
Apr. 20/77				1.2				.017	.001	.020	.42	.004	.086	133	109	.03	18.5	8.47	320			44	5.5
May 4	2.2	11.1	11.0		10	10	4	.017	.001	.008	.36	.003	.082	133	104	.62	23	8.3	330	25.5			
May 17	2.9	11.0	11.7	0.8				.019	.001	.040	.36	.002	.078	129	102	.04	26	8.31	340	26.5			
June 9	4.0	10.6	11.9	1.4	4	4	4	.018	.001	.008	.30	.001	.099	123	96	.02	27.5	8.45	330	24.5	1.2	37	7.5
June 29	2.6	7.4	18.0	1.5	4	4	4	.028	.002	.018	.42	.002	.028	110	86	.03	26.0	8.74	310	27.5	1.0	36	4.8
July 19	2.5	10.2	24.8	1.4	12	2	2	.017	.002	.030	.41	.002	.008	103	81	.02	26.5	8.76	300	27.5	1.6	29	7.5
Aug. 2	1.5			0.6				.022	.001	.026	.37	.001	.009	108	84	.03	28.0	8.34	310	27.5	1.8	31	7.5
Aug. 24	1.9	8.7	18.1					.030	.001	.016	.50	.002	.005	119	92	.04	27.5	8.31	310	25.0		36	7.0
Sept. 15	1.3	8.8	17.6	2.0				.032	.002	.022	.60	.002	.005	126	96	-	25.5	8.18	310			38	7.5
Oct. 13	1.8	10.7	9.3	1.0	92	2	2	.038	.001	.010	.53	.003	.127	137	106	.08	23.5	7.98	326	26.0		44	6.5
Nov. 30 & Dec. 19	Cancelled due to ice conditions																						
Jan. 12/78		12.9	0.0	0.2				.032	.006	.068	.42	.003	.332	147	126	.08	9.7	7.86	306	20.0	1.4	50	5.5
Feb. 1		14.2	0.3	0.2				.014	.003	.058	.47	.005	.240		122	.10		7.65	298	20.5	1.4		
Feb. 23		14.4	0.0	0.4				.022	.004	.070	.47	.005	.270		122		8.2	7.78	292	19.0	3.1		
Mar. 15		14.4	0.4	0.2				.011	.002	.058	.40	.003	.777	150	122	.16	11.0	8.00	304	20.0	3.6	51	5.5
Mean Ice-Free Period	2.3	9.8	15.3	1.2	11	4		.024	.001	.020	.43	.002	.065	122	96	.10	25.2	8.40	319	26.3	1.4	36	6.8
Mean Ice-covered Period		13.9	0.1	0.3				.020	.004	.064	.44	.004	.405	148	123	.11	9.6	7.82	300	19.8	2.4	50	5.5
Maximum	4.0	14.4	24.8	2.0	92	10	4	.038	.006	.070	.60	.005	.777	150	126	.62	28.0	8.76	340	27.5	3.6	51	7.5
Minimum	1.3	7.4	0.0	0.2	4	2	2	.011	.001	.008	.30	.001	.005	103	81	.02	8.2	7.65	292	19.0	1.0	29	4.8

*Temperature and d.o. for Station 10 at 1 m. depth.

KS/ns/REPT 4-B-6

Appendix 3, Page 5

PRESQU'ILE BAY SAMPLING RESULTS 1977 AND 1978
(results in mg/L unless otherwise noted)

	D.O.	Temp. (°C)	BOD_5	Bacteria/100 ml T.C.	F.C.	F.S.	Phosphorus Total	DRP	Nitrogens F.A.	TKN	NO_2	NO_3	Hard.	Alk.	Fe	Cl	pH	Cond. (umhos/cm)	SO_4	Turb. (F.T.U.)	Ca	Mg
Station 11																						
Mean Ice-free Period	10.3*	13.4*	1.2	12	4	3	.022	.002	.21	.36	.003	.108	122	95	.04	26.4	8.28	325	27.4	1.1	37	7.0
Maximum	12.4	19.6	1.8	24	12	4	.045	.003	.066	.49	.005	.218	132	104	.09	28.0	8.55	335	29.0	1.5	42	8.0
Minimum	7.0	7.2	0.8	4	4	2	.014	.001	.006	.26	.001	.005	111	86	.01	22.5	7.90	310	24.5	0.8	32	4.9
Station PB12																						
Mean Ice-free Period	8.37	14.8	1.3	2,128	66	57	.025	.004	.011	.648	.004	.034	275	261	1.20	17.0	8.06	566	22.0	4.37	96.6	9.0
Maximum	10.0	20.5	4.00	15,000	1,500	1,500	.075	.007	.020	1.05	.010	.100	314	312	.10	22.5	7.87	620	40.5	8.5	110	10.5
Minimum	5.2	9.5	0.50	600	8	4	.012	.001	.004	.44	.002	.005	240	233	.37	13.0	7.95	510	12.5	2.0	83	7.0
Station 13																						
Mean Ice-Free Period	8.2	18.3	1.3	354	7	24	.038	.009	.036	.78	.006	.007	170	152	.38	20.3	8.15	385	30.9	2.3	53	6.7
Mean Ice-covered Period	7.7	0.5	1.0				.015	.004	.094	.50	.019	.396	210	212	.29	15.8	7.54	478	24.1	3.1	67	6.5
Maximum	10.7	29.0	2.2	3,100	24	140	.066	.031	.164	.94	.014	.606	265	245	.86	27.5	8.46	540	39.5	5.4	92	9.0
Minimum	4.5	0.0	0.2	80	4	4	.009	.001	.004	.32	.001	.005	97	89	0.08	13.5	7.14	270	12.5	1.4	29	3.8
Station 14																						
Mean Ice-Free Period	10.0	18.2	1.1	35	3	3	.026	.002	.016	.50	.002	.019	121	98	.06	23.8	8.33	313	24.4	1.8	37	6.7
Mean Ice-Covered Period	11.3	0.4	0.6				.015	.003	.079	.52	.005	.378	124	184	.28	14.1	7.74	378	20.4	2.9	82	5.0
Maximum	14.4	26.2	1.5	310	4	4	.045	.007	.128	.69	.007	.583	225	211	.14	28.0	8.97	470	28.0	3.8	82	7.5
Minimum	7.2	0.0	0.2	4	2	2	.011	.001	.001	.42	.001	.005	94	73	.02	9.6	7.59	280	18.5	1.4	26	5.0

*Temperature and D.O. for Station 11 at 1m. depth.

KS/ns/REPT 4-B-7

Appendix 4

Station 10

Phytoplankton Results

	Ice-free 1977	Winter 1978	July 6 1978
Cyanophyceae			
Anabaena	52		71
Aphanizomenon	46	29	16
Aphanothece	1	P	
Coelasphaerium		2	
Gomphosphaeria	1		
Lyngbya		1	
Merismopedia	1		
Microcystis	56	P	
Oscillatoria	17		
Total	177	32	87
Dinophyceae			
Unid. Dinophyceae	53	9	100
Total	53	9	100
Crysophyceae			
Chrysochromulina	33	P	7
Chrysolykos		P	
Dinobyron	18	P	97
Dinobyron Cysts	8		
Kephyrion	1		
Mallomonas	9	5	
Monochrysis	3		
Salpingoeca	4		
Urogiena			63
Uroglenopsis	20		
Unid. Chrysomonads	19	6	33
Total	115	11	200

Appendix 4 (cont'd)

	Ice-free 1977	Winter 1978	July 6 1978
Cryptophyceae			
Cryptomonas	64	39	
Katablepharis		1	
Rhodomonas	37	8	3
Total	101	48	3
Euglenophyceae			
Phacus	8		
Total	8		
Chlorophyceae			
Chlamydomonas	11	4	5
Chlorella		1	
Closterium			
Coelastrum	10	P	12
Cosmarium	8		
Dictyosphaerium	1	1	9
Golenkinia		P	
Kirchneriella			14
Koliella	2		
Micractinium			4
Monoraphidium	6	P	6
Oocystis	9		
Paramastyx	2	2	
Scenedesmus	20	P	30
Treubaria	5		
Total	74	8	80

Appendix 4 (cont'd)

	Ice-free 1977	Winter 1978	July 6 1978
Bacillariophyceae			
Achnanthes		1	
Asterionella	94	12	
Cocconeis	8		
Cyclotella	57		22
Diatoma	180		
Eunotia	2		
Gomphonema		1	
Melosira	24	6	
Navicula		1	
Nitzschia	13	1	
Stephanodiscus		134	
Synedera	31		9
Tabellaria			
Total	409	156	31
Column Total (not including Zooplanton)	937×10^3	264×10^3	501×10^3
Total mm^3/L	0.94	0.26	0.50

	Ice-free Period 1977 % of total	Winter 1978	July 6 1978
Cyanophyceae	18.9	12.1	17.4
Dinophyceae	5.7	3.4	20.0
Crysophyceae	12.3	4.2	39.9
Cryptophyceae	10.8	18.2	0.6
Englenophyceae	0.9	-	-
Chlorophyceae	7.9	3.0	16.0
Bacillariophyceae	43.6	59.1	6.2
Total			

KS/ns/REPT 4-C

Appendix 5

PRESQU'ILE BAY - BENTHIC INVERTEBRATE RESULTS*

Common name (Family) Genus, species	PB3	PB6	A+	PB8	B	PB9+	C	PB10	E	PB11	F	PB14
Flatworms												
(Planaridae)	19						57	19	57		38	
Bryozoa												
Paludicella articulata									P			
Segmented worms												
(Tubificidae)	631	76			612	38	19	440	498			
Limnodrilus hoffmeisteri	P				P	P		P	P			
Tubifex tubifex								P				
Peloscolex ferox								P				
(Naididae)								77				19
Pristina aequiseta								P				
Leeches												
(Glossiphoniidae)												
Batracobdella phalera							19					
unid. immature leeches							77	19				
Scuds												
(Gammaridae)												
Gammarus	38							57			191	191
Sowbugs												
(Asellidae)												
Asellus				19	230	77	364	651	268		115	77
Mayfly nymph												
(caenidae)												
Caenis							77				19	

Appendix 5-2 (cont'd)

PRESQU'ILE BAY - BENTHIC INVERTEBRATE RESULTS

	PB3	PB6	A+	PB8	B	PB9+	C	PB10	E	PB11	F	PB14
Caddisfly larvae												
(Hydroptillidae)								19				
Oxythira							19					
(Leptoceridae)												
Leptocerus							497					
Nectopsyche								19			57	
Mystacides											19	
Midge larvae												
(Chironomidae)		38					19					
Tanypus		77										
Procladius	172			172		77			19		19	
Unid. tanypodinae	38							19				19
Chironomus	77	804	230	249	765	919	7559	344	651	19	38	
Cryptochironomus	153	38	77	57		38					38	
Parachironomus	19							38	57			
Paracladopelma	19											
Endochironomus							19		230			
Tribelos								19				
Glyptotendipes	19					77	401	19	57	77		38
Pseudochironomus												
Polypedilum	57			115					134		268	
Microtendipes										77		
unid. Chironomini	19	38				77	210	172	19	19		38
Micropsectra							77		57			96
unid. Tanytarsini	19							19		38		134
(Chaoboridae)												
Chaoborus flaviscans							19					
(Ceratopogonidae)	38			19	153				19			
Butterfly larvae (unid.)								57				
Water Mites	77							57				

Appendix 5-3 (cont'd)

PRESQU'ILE BAY - BENTHIC INVERTEBRATE RESULTS

	PB3	PB6	A+	PB8	B	PB9+	C	PB10	E	PB11	F	PB14
Snails												
(Valvatidae _valvata_)												38
Amnicola	19							77				
(Palnorbidae)												
Gyraulus								153	19		134	
(Physidae)												
Physa								38				
(Lymnaeidae)												
Lymnaea							19					
Unid.												19
Clams												
(Unionidae)										19		
(Sphaeriidae)	19											19
Total	1441	1109	307+	631	17604	1303+	9547	2294	2142	230	936	726
# of taxa	17	6	2	6	4	7	16	21	16	5	11	13

* results in organisms/m², samples taken with a 23 cm x 23 cm (9" x 9") Ekman dredge.

P = present in sample

+ numbers and variety of organisms may be underestimated because of excessive debri in sample.

KS/ns/REPT4-D-1-3

Appendix 6

LIST OF AQUATIC MACROPHYTES FOUND IN PRESQU'ILE BAY 1978

Genus Species	Common Name
Megalodonta beckii	water marigold
Brasenia	water shield
Ceratophyllum demersum	coontail
Chara	stonewort
Elodea canadensis	Canada waterweed
Heteranthera dubia	water-stargrass
Myriophyllum exalbescens	northern watermilfoil
Myriophyllum spicatum	Eurasian water milfoil
Najas flexilis	
Nuphar lutea	yellow water lily
Mymphea odorata	white water lily
Potamogeton amplifolius	bassweed
P. crispus	curly leafed pondweed
P. friesii	Fries pondweed
P. natans	
P. pectinatus	sago pondweed
P. pusillus	slender pondweed
P. richardsoni	redhead-grass
P. strictifolius	
P. zosteriformis	flat-stemmed pondweed
Ranunculus	water buttercup
Vallisneria americana	tapegrass

Appendix 7 ANALYSES OF AQUATIC PLANT QUADRAT SAMPLES FROM PRESQU'ILE BAY TAKEN JULY 25, 1978

Quadrat	Dry Wt. (g)	% L.O.I.	Ash-free Dry wt(g)	Tot. P. (mg/g)	Tot. P. (g/m^2)	Tot. N. (mg/g)	Tot. N. (g/m^2)
6A	80.75	58	46.83	1.8	0.448	18	4.48
6B	80.50						
6C	35.15						
6D	79.80						
6E	35.15						
	62.27						
7A	149.00						
7B	320.89						
7C	127.93	84	107.46	1.8	1.249	15	10.41
7D	108.25						
7E	161.42						
	173.50						
8A	87.10						
8B	59.75						
8C	79.29	74	58.67	1.5	0.437	17	4.96
8D	72.60						
8E	65.73						
	72.89						
9A	43.50						
9B	50.54	87	43.97	3.8	1.048	32	8.83
9C	129.75						
9D	67.00						
9E	54.00						
	68.96						
10A	63.08	90	56.77	2.6	0.685	20	5.27
10B	74.21						
10C	60.34						
Mean	65.88			2.3	0.773		6.79

Appendix 8 PHOSPHORUS BUDGET CALCULATIONS

Land Drainage

The supply of phosphorus coming from land drainage was calculated for Butler and Smithfield Creeks as follows:

mean monthly flow x mean total phosphorus concentration for Sta. 2 or 7

= supply for month

sum of months for study period = year supply from each watershed

The supply from the remaining watershed area was calculated using the unit flow figure for each month and the combined average total phosphorus concentration of both Butler and Smithfield Creeks for each month.

Precipitation

The amount of phosphorus entering the Bay directly from precipitation was calculated as follows:

$$\text{supply from precipitation} = 50\ \text{mgm}^{-2}\text{yr}^{1} \times \text{the surface area of the Bay}/_{10^6}$$

STP

The flow for the month was multipled by the average concentration for each month during the study period. The sum of each month is the supply for the year.

Cottages or Permanent Residences

It was assumed that the phosphorus supply from each cottage not serviced by the STP was 0.4 Kg/yr. This figure is realistic for management purposes as it is below Dillon's estimated figure of 0.61 Kg/cottage-yr (which assumed that no phosphorus is retained in the sewage disposal system), and above the figure of 0.28 Kg/cottage which Nicholls (1976) calculated as the amount of phosphorus seeping into Harp Lake from cottages.

It was assumed, based on the difference in use that the dwelling receives, that permanent residences on the shoreline of the Bay supply six times the phosphorus to the Bay that one cottage supplies.

Appendix 9 CALCULATED EFFECT OF BRIGHTON STP DISCHARGE ON THE QUALITY OF PRESQU'ILE BAY

Using the relationship of Dillon, 1975 between phosphorus supply, phosphorus retention and spring total phosphorus concentration, chlorophyll a concentration and Secchi disc depth, an indication of the effect of the STP discharge on the water quality of the Bay was predicted as follows:

conditions	water quality parameters		
	Spring T.P. (mg/m^3)	Average Chl. a (mg/m^3)	Average Secchi disc (mg/m^3)
Measured	17	-	2.3
Predicted using 1977-78 Budget	15	3.7	3.0
Predicted at STP design flow and STP effluent TP of 1.0 mgP/L	17 (13% increase)	4.4 (20% increase)	2.8 (6% decrease)

Appendix 10 PHOSPHORUS AND CHLORIDES BUDGET OF MARSH RECEIVING STP DISCHARGE

Drainage area draining to mouth of marsh at Station 9: -34.6 Km^2

Supply to the Marsh	Phosphorus (Kg/yr)	Chlorides (Kg/yr)
from land drainage	317.3	370,540
from STP effluent	1,044.4	74,569
Total	1,361.7	445,109
Supply Exiting the Marsh at Station 9	657.3	237,167
Reduction in supply	704.4 or 52%	207,942 or 47%

KS/ns/REPT 4-E-1-6